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"To promote the cause of fish culture; to gather and diffuse information bearing upon its practical success, and upon all matters relating to the fisheries; to unite and encourage all interests of fish culture and the fisheries; and to treat all questions of a scientific and economic character regarding fish."

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CONTENTS

AN EXPERIMENTAL STUDY OF THE POISONING OF FISHES BY ILLUMINATING GAS WASTES*

By Dr. V. E. Shelford
Illinois State Laboratory of Natural History, Urbana, Ill.

The work of the various investigators, both American and European, has shown that the various by-products of the manufacture of illuminating gas, as well as the effluent from ammonia sludge beds, lime and iron oxide from purifiers, etc., are poisonous to fishes. In spite of this and their great commercial value they have been and continue to be thrown into streams, especially from the smaller plants. Their marked effect upon the life of certain streams in Illinois led to the investigation of the subject by the writer under the auspices of the State Laboratory. The writer investigated gas liquors, various mixtures of coal tar compounds and thirty-two organic compounds representing the various groups. Dr. Wells investigated the two oxides of carbon.

From the usual point of view of the economic zoologist it is sufficient to know that the mixtures thrown into streams are poisonous and the matter is usually allowed to rest there. The pure science investigator however, raised further questions. Various methods of recovering and using by-products, remove certain compounds and discharge the residue,—Which compounds are most toxic and which are not poisonous? Killing experiments have usually been performed on fair sized young fish,—What stages in the life histories of food and game fishes are most sensitive? Some compounds are gases in solution which would be expected to diffuse out of water very quickly,—Do they actually escape quickly? Some compounds are regarded as insoluble and hence not to be considered,—Are they soluble enough and toxic enough

*The results of the researches will be published in full in the Bulletin of the Illinois State Laboratory of Natural History.

to destroy fishes? Fishes usually turn about and swim away when they encounter detrimental conditions occurring normally in fish waters,—Do they avoid strange poisons when they encounter them?

The relative toxicity of thirty-four compounds resulting from the destructive distillation of coal and chosen to represent natural groups, has been determined. The small Illinois sunfish (*Lepomis humilis*) weighing 4-5 grams was used as a standard fish and the concentrations used for comparison were those killing the standard fish in one hour. The following list gives the results for some of the groups of compounds in parts per million.

Compound	*Parts per million by weight to kill the standard fish in one hour.*
Amonia	7-8
Ammonia Salts	150-700
Aniline	1000-1200
Quinoline	52-56
Sulphuretted Compounds	5-125
Phenols and Cresols	50-90
Heavy hydrocarbons	2-65
Carbon monoxide (by Wells)	8

All but three of the compounds studied were found to be serious poisons. The condensed table above indicates that the removal of any class of compounds would not render the residue harmless.

In general the younger fishes down to 1.5 grams (sunfishes) are more sensitive than the larger ones. This is true for the majority of compounds but a few, as carbon bisulfide, are marked exceptions. Sollmann, using standing water, found that eggs of Funduli appeared less susceptible to poisons than either adults or embryos. His methods were faulty, however, and it is probable that his results were in part due to confining the fishes in small quantities of water. Gortner and Banta found that certain phenolic compounds were about as toxic to amphibian eggs as they are to the sunfishes used in this work

and amphibians are much more resistant than fishes. It is probable that very young fry are as a rule most sensitive, but the subject is being investigated further at this point. The most sensitive stage in the life history is the stage with which minimal fatal amounts must be determined.

The investigation showed that gases such as sulphur dioxide, hydrogen sulphide, and ethylene remain in solution in standing water for days in sufficient quantity to kill fishes. Dr. Wells showed that carbon monoxide in particular makes water toxic for weeks. Being retained by water for long periods, it ranks with the most poisonous solids in toxicity.

Compounds such as xylene, benzene, phenanthrene, and naphthalene are regarded as insoluble and hence harmless by some industrial chemists. These proved very toxic and sufficiently soluble to kill fishes in a few minutes, being among the most toxic compounds in the whole series of coal tar derivatives.

On encountering nearly all these compounds fishes do not turn back as they do in the case of the detrimental substances and conditions which occur regularly in fish waters, but swim into them without noting them and on encountering pure water again they turn back into the polluted water, even though it causes death in a short time. This is true also of the gas liquors studied and of gas in solution and is the rule in both acid and alkaline water. It is obvious from this that these types of contaminating substances are double dangerous and an earnest effort should be made to prevent their introduction into streams at all.

NOTES ON THE REARING, GROWTH, AND FOOD OF THE CHANNEL CATFISH, *ICTALURUS PUNCTATUS*

BY AUSTIN F. SHIRA, *Director*
U. S. Biological Station, Fairport, Iowa.

Though the channel catfish, *Ictalurus punctatus*, (Rafinesque), is one of the most important of the Siluridae as far as food qualities are concerned, its habits have perhaps been as little known as those of any of the catfishes. Aside from its geographical range, size, and provisional breeding season, very little information has been published.

Regarding its food value, Jordan* says, "The flesh of the channel cat, when fresh, is verp superior; it is white, crisp and juicy, of excellent flavor and not tough. It is much more delicate both in fiber and in flavor than that of our other catfishes. When well cooked, I consider it superior to that of the black bass, the wall-eye, the yellow perch, or any other of our percoid fishes. Among our fresh-water fishes it is inferior only to the whitefish, the trout, and other Salmonidae." Regarding its distribution, he further states that it "abounds in all flowing streams from Western New York to Montana and southward to Florida and Texas. It is perhaps, most common in Tennessee, Arkansas, and Missouri. It seems to prefer running waters, and both young and old are most abundant in gravelly shoals and ripples. The other catfishes prefer rather sluggish waters and mud bottoms. I have occasionally taken channel cats in ponds and bayous, but such localities are apparently not their preference. They rarely enter small brooks, unless these are clear and gravelly. Whether they will thrive in artificial, ponds, we can only know from experiment." With refer-

*David S. Jordan. "The Habits and the value for food of the American channel catfish (*Ictalurus punctatus*, Rafinesque). Bull. U. S. F. C., 1885., p. 34.

ence to its habits, he says, "It is a carnivorous fish, although less greedy than its larger-mouthed relatives. It feeds on insects, crayfishes, worms, and small fishes, and readily takes the hook. It spawns in the spring, but its breeding habits have not been studied."

More recently, Forbes and Richardson* give its range as "throughout the Mississippi Valley, the Gulf and Great Lakes region, and northward to Ontario and Winnipeg, being especially abundant in the Red River at the latter place. Southward it extends to the Alabama River and the Florida peninsula, Louisiana, Texas, and the Rivers of northern Mexico." The food of 43 specimens examined by them consisted of insects, (larvae and adult) principally aquatic, 44 per cent, vegetable matter, 25 per cent, and Mollusks, 15 per cent. The remainder consisted of fishes, animal debris, and stillhouse slops. Most of the aquatic insects were larvae of may-flies, dragonflies, and gnats, though now and then a fish had fed wholly on terrestrial forms.

In a letter to Prof. S. F. Baird as published in the Bulletin of the U. S. Fish Commission for 1884, J. F. Jones of Hogansville, Georgia, writes of his success in raising the "speckled catfish" in a five-acre pond but it is not perfectly clear that he had the channel cat, *I. punctatus*, in mind, as his fish may have been a species of *Ameiurus*. In his paper on the "Habits of some of our Commercial Catfishes,"† W. C. Kendall refers to the "speckled catfish" of Jones as the channel cat-fish, *Ictalurus punctatus*, but one feels some hesitancy in basing the identity on the meager and confusing description of the fish and its habits given in Mr. Jones' letter.

The following account of the spawning of the channel, or spotted catfish, in an aquarium is taken from the Report of the Commissioner of Fisheries for 1911. "During the summer of 1910 an excellent opportunity was presented of observing the reproductive habits of the spotted

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*Forbes and Richardson. "The Fishes of Illinois." Natural History Survey of Illinois. Ichthyology, Vol. III, 1908.

†Bull. U. S. Bureau of Fisheries, 1902, p. 406.

catfish, a subject about which little definite information has been obtainable. On July 9, between the hours of 9 and 10 A. M., a pair of these fish confined among others in a large aquarium in Central Station (Washington, D. C.) were seen to be in spawning condition. They had prepared a nest 8 to 10 inches in diameter by removing the gravel from the bottom of the aquarium, leaving the bare slate exposed. On this space the female deposited a mass of eggs, estimated at 3,000, but all except 50 of the eggs were devoured before the other fish could be removed from the tank. The remaining eggs were taken in charge and tenderly cared for by the male parent, the female apparently taking no further interest in the proceedings. On the fifth day 41 fry were hatched, the water temperature for the period averaging 81° F. The young when hatched were three-eighths of an inch long and of a whitish-pink color, which gradually became darker, assuming a light slate by the eighth day. At 4 days old they became very strong and active, and on the seventh day were fed canned herring roe, to the exclusive use of which is attributed the loss of 29 within 3 days. Beef liver was then substituted. The remaining twelve throve on this diet, reaching a length of 3¼ inches by the middle of November, when the water temperature dropped to 40°F. They then refused food and hibernated in a little cluster in one corner of the aquarium. Early in February the fish were attacked by fungus which caused the death of 8. The other 4 were in the aquarium at the close of the year and apparently healthy, being 4 inches in length." This is undoubtedly the first authentic record of the breeding of the channel catfish.

For several years the Bureau of Fisheries has attempted to rear the channel cat in ponds at several of its stations, but until it was attempted at the Fairport Station, no successful results had been obtained. The first experiments were started at this station during the season of 1914, in one of the ponds designated as 16 B. This is an earth pond 0.195 acre in area, rectangular in form, with a maximum depth of 6 feet and 10 inches. This

pond was stocked with 66 brood fish of medium size, April 24, 1914. These fish were fed cheese and river minnows weekly throughout the summer, but aside from the feeding no further attention was given them. On November 23, 1914, the pond was drained and in addition to the 66 adult fish recovered, 9 young were obtained. The experiment was continued the following Spring with the same stock of brood fish, less 5 which had been removed. On November 23, 1915, the pond was drawn and, in addition to the 61 adults recovered, an increase of 7 young was noted, measuring from 4 to 8 inches in length.

From the standpoint of numbers of young produced, the work during these two years was not at all satisfactory, but from the standpoint of size the results were quite encouraging. The fact that the young catfish reached a maximum length of 8 inches indicated that they did well in the pond and, if numbers as well as size could be obtained, the problem would in a large part be solved.

Accordingly, it was determined to continue the experiment another year and keep a closer check, if possible, on the pond. Thinking that perhaps the fish might do 'better in a larger pond, it was decided to use Pond 9 D, the only large pond available, even though it was a new pond. This pond has an area of 0.681 acre and a maximum depth of 7 feet. On May 3, 1916, 34 channel catfish were placed in the pond, some of these fish being brood stock saved from the preceding season and others having been obtained from the Mississippi River during the fall and retained over winter. Four nail kegs to serve as nesting sites were placed in the pond banks at a slight angle above the horizontal and slightly above the bottom of the pond. No vegetation was placed in the pond and throughout the season no growth of aquatic plants except filamentous algae occurred.

In order to keep a closer check on the experiment and note the results being obtained, it was decided to drain the pond about July 1, if necessary, to learn whether or not any increase had been obtained. As the water which supplies the ponds is taken from the river,

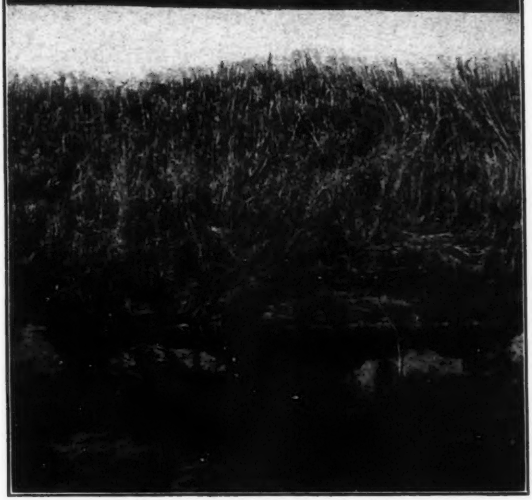


FIGURE 1. Showing position of keg in which a nest of eggs of the channel catfish was found July 6, 1916, after pond was drained. Pond 9 D, U. S. Biological Station, Fairport, Iowa.

FIGURE 2. Hole in the bank of Pond 9 D, which may have been made by the catfish and used as a nest, July 6, 1916.

it is usually so muddy, or roily, during the spring months, that it is difficult and at times impossible to observe the nesting of the pond fishes. Thus in planning the season's work it was decided that, if no information regarding the spawning of the fish could be obtained by observation, the pond would be drawn as an extreme measure, though it was realized that a sacrifice of a large quantity of the food elements of the pond would be entailed. The tentative date for draining the pond was set as July 1 for two reasons:—

1. It was thought that this would give ample time for the lapse of the spawning and hatching period and still be sufficiently early to obtain any young that might be in the pond and separate them from the adults before they had made very much growth.

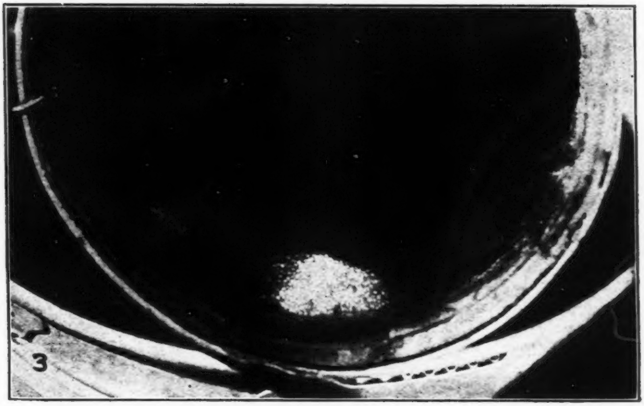
2. If it was ascertained that spawning had taken place, and yet no young were found, there would still be a sufficient portion of the season remaining to utilize the pond to very good advantage in other experiments.

During the spring a very careful watch was kept on the pond, but no evidence of spawning was noted and, in truth, it would have been very difficult to have detected such evidence. Not deeming it advisable to get in the pond with a seine, it was determined to slowly draw off the water. This was done and July 6 the water was sufficiently low to lay bare the greater area of the pond bottom. On walking along the pond-bank, Mr. H. L. Canfield, Superintendent of Fish Culture, saw one of the adult catfish lying in the shallow water and about a foot behind the fish he noted a very compact school of fry. From its size and appearance, the fish was estimated to weigh about three or four pounds. On closer approach the adult fish made a splash and retreated to a deeper portion of the pond, roiling the water considerably by its movement. As the water gradually cleared, the fry were still seen schooling in the same place. One of the kegs placed for nesting was nearby and when examined was found to contain a number of fry, evidently the remains of the school outside which had left

the keg. These fish were estimated to be about one-fifth of the school. The keg was then about a foot out of the water, but it still held some water left in as the pond was lowered. On being advised of the discovery the writer went to the pond and the small, compact, grayish school of fry was still in sight.

Another keg with the lower edge of the opening just about level with the water surface, and located nearer the outlet of the pond, was then examined and it was found to contain a mass of yellowish eggs, approximating a single handful. The eggs formed a very glutinous mass not resting at the lowest point in the keg, but adhering to the lower slightly sloping side near the mouth. A few of the eggs were removed and well-developed and active embryos were seen inside the egg cases. An attempt was made by Mr. Southall to photograph the school of fry in the pond, but owing to the roily water and the efforts of the fry to get under masses of algae, the efforts were unsuccessful. However, pictures were taken of the kegs in situ (Fig. 1) and also of a hole in one of the pond banks (Fig. 2) that appeared to have been made by some of the catfish, perhaps for nesting purposes. As the water in the pond was getting quite warm, the keg with the eggs was removed to the tank house where a picture was taken of them (Fig 3). The eggs were then carefully tempered from a temperature of 90° F. to 72° F. and placed in a Downing hatching jar at 6:00 P. M. As many of the fry as it was possible to secure were obtained and also placed in the tank house. Later they were placed in a round glass dish and a photograph taken of them (Fig 4).

Several of the eggs had hatched the following morning; prematurely no doubt and probably caused by the handling of the preceding day. A large number of the eggs hatched on the 8th. On the morning of the 9th several of the fry were found dead apparently having been smothered under the egg mass. Unlike the fry of the pike perch, or buffalo fish, they do not rise after hatching, but keep close to the bottom and as there was no



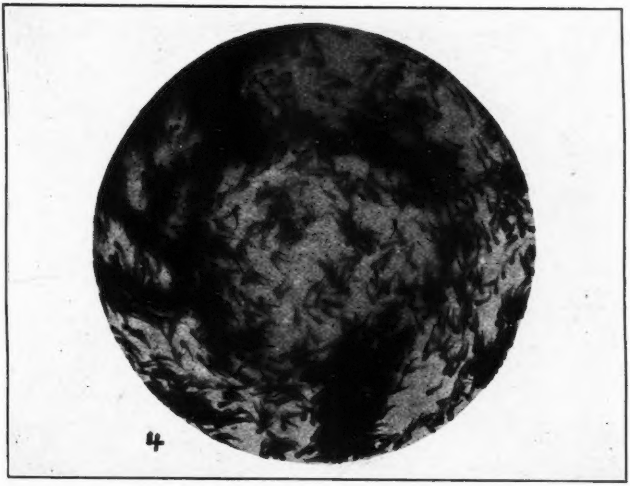


FIGURE 3. Showing the eggs of the channel catfish in original position in keg as found in Pond 9 D, July 6, 1916. Keg and eggs carried to tank house in tub of water and there photographed.

FIGURE 4. Fry of the channel catfish, *I. punctatus,* found in Pond 9 D, July 6, 1916. Photographed in glass dish.

flat surface in the jar upon which they could rest they congregated in a dense mass at the lowest point in the jar under the unhatched eggs. In an effort to remedy this, the eggs were removed to a round, rather flat-bottomed glass aquarium of about 6 litres capacity, supplied with a tube from the hatching battery. This gave the fry an opportunity to scatter out over the bottom of the glass vessel and no further loss resulted. By 5:00 P. M. on this same date all had hatched, 706 strong and healthy fry having been obtained. In addition, 164 fry had died and 150 eggs had been lost during the hatching period, making in all 1,020 eggs that had been removed from the nest in the pond.

The eggs averaged 3.53 mm. (about 0.14 of an inch) in diameter and the young when hatched were about one half an inch long, were quite slender, and very transparent. The yolk sack was quite large and oblong, making up about ¼ the length of the fish, and of a rather light amber color. By July 13th, the yolk sac was almost wholly absorbed. The fry kept very close to the bottom of the container and made little effort to rise.

Of the fry that had hatched in the pond, 2,861 were obtained. Of this number 802, including those found dead in the keg, were lost in the process of handling, due to the fact that they were entangled in dense masses of algae from which they were removed with difficulty. The temperature of the water at the time of removal was 95° F. Of the 2,059 living ones, 1,717 were returned to Pond 9 D, July 8, after removal of adults; 300 placed in Pond 1 E, July 8, a new pond with an area of 0.046 acre; 30 placed in an aquarium, and the remainder preserved for specimens. The 706 fry hatched in the jar were disposed of as follows:—300 placed in Pond 4 E, July 11, a new pond with an area of about 0.046 acre; 374 placed in Pond 9 D with the older fry, July 11; and the remainder preserved as specimens.

Growth

Beginning July 25, collections, almost weekly, have been made in the ponds, and the young fishes secured

TABLE I. Showing the growth made by young channel catfish, *I. punctatus*, in ponds at the Fairport Biological Station, 1916.

Date	Number Measured	Pond 1 E			Date	Number Measured	Pond 4 E			Date	Number Measured	Pond 9 D		
		Smallest in.	Largest in.	Average in.			Smallest in.	Largest in.	Average in.			Smallest in.	Largest in.	Average in.
July 6	12	0.5	0.56	0.52	July 9	10	......	......	0.85	July 6	12	0.5	0.56	0.52
July 25	9	1.5	1.65	1.63	July 25	10	0.8	1.26	1.14	July 27	5	1.7	1.85	1.78
Aug. 5	5	2.34	2.56	2.48	Aug. 5	5	2.0	2.31	2.2	Aug. 5	5	2.28	2.5	2.34
Aug. 12	5	2.87	3.06	3.01	Aug. 12	5	2.6	2.93	2.8	......	..	......	......	......
Aug. 19	5	3.19	3.48	3.28	Aug. 19	5	3.1	3.37	3.15	Aug. 18	5	2.65	3.12	2.86
Aug. 26	5	3.47	4.06	3.63	Aug. 26	5	3.34	3.56	3.45	Aug. 26	5	2.93	3.47	3.44
Sept. 2	5	3.75	4.37	4.05	Sept. 2	5	3.43	3.81	3.65	Sept. 2	5	3.06	3.78	3.44

Note.—The first row indicates the date and size of the fish when originally taken from Pond 9 D and the hatching jar and not the date and size when placed in the ponds, which was July 8, for Ponds 1 E and 9 D, and July 11 for Pond 4 E. Some slight increase in size would be expected during the intervening days.

TABLE II. Food of young channel catfish, *I. punctatus*, taken from the ponds at the Fairport Biological Station, July 27 to Sept. 2, 1916.

Pond No.	Fish		Chironomus larvae	Ephemerida larvae	Corethra larvae	Dragonfly larvae	Damselfly larvae	Dytiscus larvae	Dipterous pupae	Entomostraca	Ooze and debris	Filamentous algae	Unidentified remains	Rotifers	Tanypus (Midge) larvae	Hemiptera (adult)	Notonecta (larvae)	Lepidoptera (larvae)	Caddis-fly (larvae)
	No. examined	Length in inches																	
1 E	25	1.5-4.18	55.9	9.4	x	x	x	x	3.9	4.0	17.9	trace	x	trace	x	....	....	....	....
4 E	26	0.8-3.81	60.9	7.6	x	x	x	x	7.3	3.5	15.0	x	x	....	x	x	x	x	x
9 D	21	1.7-3.78	28.0	34.5	x	3.5	....	x	2.2	6.0	16.5	7.8	x	....	....	....	....	....	....

Note.—An x indicates that the item of food was present, but the percentage was not computed.

have been measured and the stomach contents examined. The growth made by the fishes in the three ponds, up to September 2, is given in the following table.

Referring to table No. 1, it will be noted that the fish reached the largest size in Pond 1 E where a maximum length of 4.37 inches and an average length of 4.05 inches had been obtained by September 2, being an increase of 3.81 inches an 3.53 inches over the original measurements started with. This is quite a remarkable growth to be made in approximately two months time. Though smaller at the commencement, the fish in Pond 4 E had reached a greater size by August 19, than the ones in Pond 9 D, and continued in the lead. As the fish in Pond 1 E had also grown faster than the ones in 9 D, the natural supposition would be that there was less available food in the latter pond, per number of fish, than in the two other ponds.

Food

The stomach contents of the fishes taken in the weekly collections were examined by Mr. N. K. Bigelow, temporary scientific assistant, and the following data on the food have been compiled from the detailed notes supplied by him. Table No. 2 gives the total number of fish examined, the size ranges for each pond and the percentages in which the various food items occur.

Referring to the foregoing table, it will be noted that by far the greater part of the food of the fish in Pond 1 E was composed of insect larvae, fully 74 per cent consisting of these forms. *Chironomus* larvae was the most important item of food, 55.9 per cent of the total food taken consisting of these forms. *Ephemerida* larvae were taken in less numbers, making up 9.4 per cent of the food. Collections of the various forms in the pond made by George B. Lay, temporary scientific aid, revealed the presence in considerable numbers of both *Chironomus* and *Ephmerida* larvae. Thus it would seem that the exceedingly larger number of *Chironomus* larvae was taken more from choice than the fact that the *Ephmerida*

larvae were not available. The fact that such a large per cent (17.9) of ooze, or silt and debris, was taken is very interesting and brings up the question whether it was taken by selection, or incidently with the other items. The first appearance of the ooze was noted in the fishes taken August 12, a total absence having occurred in the two previous collections.

With few exceptions the food taken by the fish in Pond 4 E was very similar in kind and amount to that obtained in 1 E.

In Pond 9 D, also, the greater part of the food taken by the fish consisted of insect larvae, but in this pond the *Ephmerida* larvae made up the largest single item, forming 34.5 per cent of the total food taken. This is a striking difference as compared with the much lower percentages of these forms in the fishes from the other two ponds. Collections of the animal life in the pond revealed the fact that *Ephmerida* larvae were quite abundant and *Chironomus* larvae much less so. The fact that *Chironomus* larvae made up 28 per cent of the food of the fishes in a pond in which they occurred in much less numbers than the *Ephmerida* larvae which made up 34.5 per cent of the food, would seem to indicate that, when obtainable, *Chironomids* are the favorite food. The large per centage (7.8) of filamentous algae taken in the food of fishes from this pond, is no doubt accounted for by its great abundance in this pond, and its almost complete absence in the other two ponds. Though considerable algae would undoubtedly be taken incidentally with the other items of food, there is perhaps little doubt that it is directly taken to some extent by the fish as food. Dragonfly larvae made up 3.5 per cent of the food in this pond, while they were merely represented in the food of fishes from Ponds 1 and 4 E.

Briefly comparing the food taken by the fish in the three ponds, it will be noted that the food of the fishes from Pond 9 D differed from that of the other fishes, principally in the larger amount of *Ephmerida* larvae taken, with corresponding decrease in *Chironomus* lar-

vae; and in the greater amount of *Entomostraca,* algae, and *Odonata* larvae. The collections of animal forms from the ponds indicate that the fish were feeding with but little discrimination on the available food, the percentages of the various forms in the food taken by the fishes in each pond being a very good index as to their abundance in that particular pond.

The experiments with the catfish are being continued and it is hoped to carry them to completion.

A SECOND GENERATION OF ARTIFICIALLY REARED FRESH-WATER MUSSELS*

BY DR. A. D. HOWARD, *Fairport, Iowa.*

At the annual meeting of this Society in 1914, I presented the results† of a method devised for rearing early stages of fresh-water pearl mussels. Subsequent results indicate that the method with modifications is equally favorable for later stages in the life history. The means employed was a floating crate containing baskets of sufficient size to hold the infected fish and made of small enough mesh to retain the microscopic mussels as they escaped from their hosts.

The crate, supported by floats, was placed in the river (the Mississippi) in a good current. A crate thus held at the surface, in addition to other advantages, accommodates itself to any rise or fall of the river, is convenient of access, and removes the young mussel from many enemies on the bottom.

For the early stages, the baskets consisted of a framework of galvanized iron or wood, attached to a base of the same material. On the frame was stretched copper cloth of one hundred mesh to the inch. As the mussels increased in size, it seemed desirable to use netting of larger mesh for the baskets in order to permit a freer circulation of water.

At the end of the first season, period of growth 5 months, the maximum growth was a length of 32 mm., an average of 25.5 mm. which far exceeded the highest previous record for growth under observation, viz. that by Herbers, who obtained a growth of 3.13 mm. in *Ano-*

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*Contributions from the U. S. F. Biological Station, Fairport, Iowa. Published by permission of Commissioner of Fisheries.

†Howard, A. D., 1914. A New Record in Rearing Freshwater Pearl Mussels. Trans. American Fisheries Soc., December, 1914.

donta cellensis, Schröt, while conducting studies on the embryology of that mussell.††

The results in growth indicate that the method provides a close approach to a natural environment and thus furnishes a means of readily following the life history. In this way we have been able to determine features that were not accurately known before.

It is not my purpose here to take these up in detail but we may indicate the events and their chronology up to the second generation which may be considered a completion of the life cycle. Glochidia were taken May 21st from the Lake Pepin mucket, *Lampsilis luteola* Lamarck, and fish infected with them on this date. The parasitic period lasted for 18 to 20 days or until June 9th, The extensive and remarkable changes of this stage take place in an even shorter time under some conditions. In this species the mussel makes no increase in size during metamorphosis. Thus at the beginning of free life, it is very small and becomes easily a prey to numerous enemies. This period, therefore, is critical in the life of the mussel, perhaps as much so as that of the larva.

The period of development succeeding metamorphosis from the beginning of free life up to the attainment of the adult condition comprises what is called the juvenile stage. The shell of juveniles, up to the second month, has two features that are characteristic of this early period. In consistency, it is like horn, being transparent and less hard than later when it becomes calcareous. The surface is usually uneven owing to a series of regular and relatively high undulations, knobs, etc., which are characteristic for each species. These are designated as "Umbonal sculptures" by conchologists in describing the adult mussel, in which they are not infrequently found well preserved. Another structure to which I wish to call attention is the byssus, an organ that is characteristic of the juvenile stage in certain groups of fresh-water mussels. It consists of a hyaline thread produced by the

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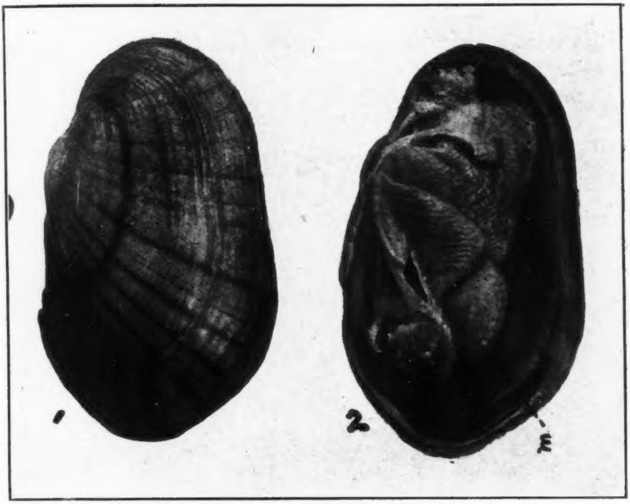
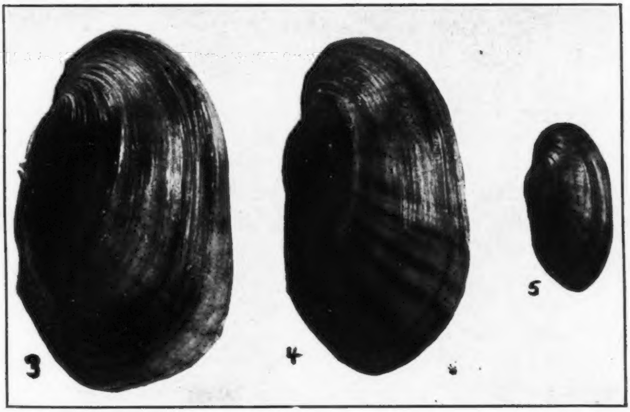
††Herbers, Karl: 1913, Entwicklungsgeschichte von *Anodonta cellensis* Schröt. Zeitschrift, Wiss. Zool. Bd. 108 Heft. 1.





FIGS. 1 AND 2. An adult and gravid female (*Lampsilis luteola* Lam.) grown in nature. The right shell and mantle were removed to expose the soft parts of the mussel. At *M* may be seen the marsupium a modified portion of the outer gill in which the young are carried from the egg to the glochidial stage. Photograph natural size; by the author.

FIGS. 3, 4 AND 5. Mussels of the same species as in Fig. 1, reared under control in a crate, from glochidia metamorphosed on artificially infected fish. The mussels are in their first, second and third years, respectively. Photograph natural size; by J. B. Southall and the author. Fig. 3, is a gravid female at the age of first breeding two years and sixty-seven days after metamorphosis.

byssus-gland located on the ventral and posterior median edge of the foot. I have observed this thread in mussels under 3 mm. and it was found as late as the end of the first year in this culture. A month later no further trace of it could be found.

During the second year, noticeable features were the rapid growth and the appearance of sexual differentiation in secondary sexual characters. Modifications of the gills to form the marsupium appeared in the female together with the corresponding fullness of the shell over that organ. For growth the maximum length of shell observed was 62.8 mm. (about 2½ inches) nearly double that of the first season (32 mm.) measured in November. To test the commercial value of shells at this age buttons were cut from a few. A 16 line button, 2 lines thick, was produced. This is rather too thin for commercial purposes but it shows that a growth of two years is quite appreciable.

The middle of August of this year, the third summer, the first gravid mussels were found. This, the first observed breeding date, was two years, two months, and 24 days from the date of implantation of the larval mussel upon the fish. All females, as far as examined, were found to be gravid; these were picked up at random from the crate so the indications are that breeding is general at this age. The glochidia were mature in some individuals on August 14th and near maturity in others, which from the date of the last observation would fix the time of ovulation as July. Mature glochidia from these mussels were taken and an implantation obtained on a number of fish. The first free juveniles after metamorphosis were obtained in ten days, others remained as late as the 18th day, a rather long period of shedding. The juveniles secured represent the second generation of mussels, but the life cycle was completed when glochidia were mature, as that was the stage with which the experiment began.

A comparison was made of a crate-grown shell with one grown in nature. In these two mussels of the same

linear dimensions, the same sex, and all marks indicating them to be of the same age, the advantage of weight was with the artificially reared shell. This is a limited comparison, but as neither of the shells was selected, it is good so far as it goes. The thriving condition of the mussels is an index of the value of the method. I know of no other plan yet devised that gives as favorable results. For experimental purposes, pearl culture, or for even the commercial production of mother-of-pearl, the method seems to offer exceptional possibilities.

AN ARTIFICIAL INFECTION WITH GLOCHIDIA ON THE RIVER HERRING*

By Dr. A. D. Howard, *Fairport, Iowa.*

The River Herring, *Pomolobus chrysochloris* Raf., was one of the first fish recognized as a restricted carrier (Surber, 1913, Howard, 1912, 1914a, 1914b) of a given species of mussel. During three summers or more previous to 1912, experiments were carried on by the U. S. Bureau of Fisheries to determine some method for propagating the Quadrula mussels and particularly the niggerhead, *Quadrula ebenus* Lea, considered the best of the group for commercial purposes. In this case, unlike some other mussels that had been tested, a persistent implantation of glochidia could not be obtained upon those species of fish usually employed for propagation. A systematic search was instituted to find if possible a natural host. The discovery, on the river herring, of a natural infection by glochidia of the niggerhead mussel (Surber, 1913) seemed to solve this particular problem.

After the finding of the parasitic relation between this species of fish and mussel, attempts were made to obtain artificial infections. It was planned to transport the fish to an artificial pond and there to hold them after infection, until the glochidia should develop. Entirely negative results were reported owing to the immediate death of the fish at the time of capture.

This sudden dying of the fish has been ascribed to various causes. The first of these to come to mind would be lack of oxygen, as the fish is very active and has relatively large gills, in a small body of water it must soon ex-

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*Contribution from the U. S. F. Biological Laboratory, Fairport, Iowa. Published by permission of Commissioner of Fisheries.

Acknowledgements are due: Messrs. A. F. Shira and Mr. H. L. Canfield for helpful suggestions and assistance; to Mr. W. F. Teachout and crew for their efficient conduct of operations; to Mr. Zack Nyhart of Lake City, Minn., for courtesies extended.

haust the oxygen supply. Related to this would be an unusual sensitiveness to carbon dioxide or other products of respiration. Another cause suggested is the purely nervous reaction of fright with its consequences which seems to cause almost instant death with some species of fish.

In a discussion of the problem of artificial infection (Howard, 1914) the writer suggested a method for carrying out the experiment. This was to hold the fish in a pound net made of a seine in waters favorable to the development of the mussel, infecting without removal from the water if necessary. Last year the opportunity came for trying out this plan. On the proposal of Mr. Shira, Director of the Biological Station, Fairport, Iowa, the writer, in company with Mr. H. L. Canfield, Superintendent of Fish Culture, went to Lake Pepin where a few of the herring were being taken in connection with the propagation of mussels carried on in this lake by the U. S. Bureau of Fisheries. The following plan was carried out: A fish-pound was constructed at a protected place in the lake, as near as practicable to the point where the fish were to be taken in order to reduce the carry to a minimum. The lake is a widening out of the Mississippi River but has the characteristics of a true lake. The length is 25 miles, the maximum width, 2½ miles. No river-current is perceptible and the water reaches a maximum depth of 56 feet. As the fishing operations are carried on at one of the wider places, it was necessary to select a protected site for the pound where the fish and any mussels shed from them would escape wave action. A fortunate location was found convenient to the seining beach and near the head of a bay where the only wave action possible was from directly across the lake, a quarter from which rough water can scarcely develop to an injurious extent. The pound was constructed by fastening a 300-foot seine to stakes driven into the bottom. A depth of 4 to 6 feet met the requirements in most respects and consequently the difficulties of construction for greater depths were avoided.

At the time I visited Lake Pepin, August 5th to 8th, herring were being taken each day, averaging only about a dozen per day. Wagner in his report on observations made in 1904 upon the fishes of Lake Pepin (Wagner, 1908) calls this species exceedingly abundant at that time. My Nyhart told me that he had not seen many for over five years. They are of no known commercial value, so ordinarily are allowed to escape.

The method of capture was somewhat unusual. Mr. Zack Nyhart operates here a three thousand foot seine of large, (3 inch) mesh in which the principal catch seemed to be buffalo-fish, German carp, pickerel, paddle-fish, and sheepshead. As the large seine approaches the shore the "propagation crew" of the Bureau of Fisheries extends a 200-yard seine around it, thus capturing a number of game fish which escape through the large net when the area enclosed becomes restricted. Ordinarily the U. S. Fisheries crew hold their catch impounded temporarily in their seine and infect the fish in lots appropriate to the size of their infecting tank, a container of galvanized steel with a capacity of 3¾ barrels.

For this experiment the herring were transferred by hand or dip-net to the tank and taken, with the least possible delay, in a gasoline launch to the pound. During this run, which took 5 minutes, infection was carried on, the glochidia having been put into the tank prior to the introduction of the fish. In the first attempted infection and transfer, all the fish, thirteen in number, were transported at one time. As it required several minutes to separate the herring from the other fish, those first introduced were subjected to a much longer confinement than the last. In this case out of 13 carried, only 4 were alive at the end of the run. In the second attempt a total of 14 were carried in three trips instead of one, with much better results, the total mortality being only 4. In all the runs the tank was kept covered, on the suggestion of Mr. Canfield, to keep out the light and to reduce the factor of fright. I have not, myself, had an

opportunity to determine experimentally to what extent this precaution affects the result.

With the herring were infected a few mooneyes, *Hiodon tergisus*, Le Sueur. Both species seemed to take the infection but subsequent examination showed that the glochidia were retained by the herring only. Although a sensitive fish, the mooneyes stood the transportation much better than the herring.

The success of the simple method which we followed was greater than anticipated. I had expected, in case it failed, to try a live car and even an anaesthetic for the fish during the infection.

The glochidia used in the experiment were obtained from mussels shipped by mail from Fairport, Iowa. Of three shipments, two coming in cool weather were in fair condition, the third in warmer weather was spoiled. In this experiment the long shipment (time of transit 14 hours) was made for reasons of immediate convenience, a much nearer source of supply might have been found, as the niggerhead mussel occurs in considerable numbers in the river just below the outlet of the lake. I found *Q. ebenus* in shell piles well up the lake, but it is apparently quite rare. Its presence, however, in a natural state, indicated that the conditions were such that the attempt to rear it experimentally in the lake would be feasible.

Upon completing the infection, Mr. Teachout, foreman of the crew, was left in charge of the fish in the pound. In accordance with instructions, at stated intervals, he killed fish and forwarded the gills for examination. Three shipments were made, the last being ten days after the last infection. Each lot showed the infection and the latest showed considerable development of the young mussels. In these, when prepared for microscopic examination, the following organs, liver, adductors, foot, and gill-papillae, were visible.

Gills of the fish killed immediately after the infection show the manner of attachment and cyst formation which are somewhat peculiar. In *Pomolobus,* we have

unusually wide lamellae on the gill-filaments. The glochidium in clamping upon these, will include usually four or more lamellae within the bite of its valves. Thus several lamellae will be enclosed in a cyst which is for the most part a solid mass of cells. Sometimes the space between lamellae persists proximally within the otherwise homogeneous and solid cyst. Such spaces would explain the phenomena which Surber (Surber, 1913, p. 111) called "migration of the glochidium," and further described as follows, "Simple, hollow, globular areas, suggesting small tumors, unmistakably the former abode of some young mussel." The same globular areas are to be seen in the herring, in infections by glochidia of the Elephant-ear mussel, *Elliptio crassidens* (Ort.). The more simple explanation which we have offered seems to be supported by the appearances in many cases and to make necessary the theory of migration which is unknown for larval mussels on other fish.

Eight days after the last shipment of gills from the impounded fish, a report was received that the remaining *Pomolobus* had escaped. This unfortunate occurrence prevented the determination of the full period of parasitism. The writer has determined that this period is the same for three different species of mussel, (*Lampsilis ligamentina, L. luteola,* and *L. anodontoides*) under like conditions. (Howard, 1914b). The period was 20-21 days (May 22 to June 10 and 11)—that is, the three were carried parallel through the metamorphosis, having the same date of infection and being held in the same pond. To that extent, conditions were similar. The one factor varied was the use of different hosts. This summer I observed a short period of 7 days for *Quadrula plicata,* but at the average high temperature of 90° F. (32° C.). I have seen indications of a difference in the parasitic period for widely separated species but know of no demonstration of it. The amount of development during the ten to twelve days of observations in the present experiment, indicates that the period of metamorphosis in *Quadrula ebenus* corresponds rather closely with

that of other species that have been investigated. The shortest periods observed are seven days for a summer-breeder and 10 days for a winter-breeder, the young juveniles being recovered in each case.

In four shipments of gills from the mooneyes, no infections were found. It was hoped that this abundant and more easily handled fish would prove favorable, but like other species tested with one exception, the glochidia were dropped under 3 days. The other fish that have been tested are, the Sand Sturgeon, *S. platorhynchus;* Dogfish, *A. calva;* Spotted cat, *I. punctatus;* Bullhead, *A. nebulosus* and *A. melas;* Yellow cat, *L. olivaris;* White Crappie, *P. annularis;* Black Crappie, *P. sparoides;* Blue Spotted Sunfish, *L. cyanellus;* Bluegill, *L. pallidus;* Large Mouthed Black Bass, *M. salmoides;* Yellow Perch, *P. flavescens;* Sheepshead, *A. grunniens.* The exception referred to was the Gizzard Shad, *Dorosoma cepedianum,* Le Sueur, which gave some indications of being favorable. The results being inconclusive, however, demand further trial. But even should it be found to carry the mussel, the protection afforded by the very fine gill-rakers render infection impracticable by the ordinary method.

Summary of Results and Discussion.

The results substantiate the findings in natural infections, viz. that the herring is a carrier of the nigger-head mussel.

The Mooneye, *Hiodon tergisus* Le Sueur, gave negative results as reported for a considerable number of other species when tested with the glochidia of the niggerhead mussel.

The possibility of artificially infecting the herring was demonstrated, as well as a method for holding it in captivity.

The parasitic period of *Quadrula ebenus,* under the conditions prevailing at the time of the experiment, was shown to be more than ten days, but the amount of de-

velopment in this time indicates that the period of metamorphosis is not of exceptional length.

The clear globular cysts observed in infections on the herring are due to structural peculiarities of the gill, modified by cyst formation, rather than to migration of the parasite.

Taking into account the present scarcity of the River-Herring in rivers where it was formerly abundant, it would seem practicable only to attempt propagation where fish and mussel are abundant. This and other considerations would warrant a reiteration of the views advanced by the author in 1913 (Howard, 1914a). "The remarkably full infection of this species in nature indicates that under natural conditions propagation of the mussel will take care of itself. Thus recommendation of measures for preventing the extermination of the niggerhead mussel would be along the line of protection of the herring as the host fish. The cause for the increasing scarcity of the herring seems not to be due to capture in large numbers as the fish is not commonly used for food throughout its range. It is more probable that it is due to artificial conditions, such as the obstruction of its natural migrations by dams, and the introduction into the rivers of injurious wastes from manufacturing plants, etc."

Without a more exact knowledge of its present status, we can not say how far these things affect this species. We must look with interest for studies upon the occurence of this fish, its migration and breeding; in fact, a knowledge of its whole natural history is required, for though not itself esteemed, on it depends the niggerhead mussel and the welfare of an important industry.

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THE TOP MINNOW, (*GAMBUSIA AFFINIS*)

By E. N. Carter,
Superintendent, U. S. Fisheries Station, Bullochville, Ga.

The range of this species of top minnow, *Gambusia affinis*, as given in Economic Circular No. 17, of the U. S. Bureau of Fisheries by Mr. Lewis Radcliffe, is from New Jersey to Florida on the east, from Illinois to Louisiana on the west and thence to the rivers of Texas and Mexico. In size they are from an inch to an inch and a quarter in the males and from an inch and a half to two inches and a half in the females. The adult male is distinguished from the female by the long bayonet-like anal fin of the former.

They seem to prefer the shallower waters and when observed are always in motion, swimming hither and thither among the grass and weeds which line the edges of the ponds or streams. They are not so graceful as the young bass or sunfish. The constant motion makes their swimming seem almost laborious, as though impelled by a force over which they have no control. Their small bodies are like animated steel springs and they flip from the net or seine in which they are taken as if snapped from beneath with one's finger. Yet with all their wonderful activity and their ability to survive under the most trying circumstances, they are frail and will stand little handling. Hands off and they will live in cold, spring water and in small pools of very warm water, such as are formed by boot tracks in the soft mud of a pond that has been drained the previous day and left exposed to the sun.

In his waking hours *Gambusia affinis* is a constant searcher for food, a habit which makes this insignificant creature a blessing to mankind, at least to that portion of mankind unfortunate enough to dwell where the mos-

quito thrives. No sensible, self respecting *Culex* or *Anopheles,* would lay her eggs where this mighty little destroyer swims. The wiggler is the choicest tid bit of the top minnow and the federal authorities have wisely chosen him as an exterminator, within his range, of this universal pest which is a menace to health and happiness.

In the U. S. Department of Agriculture Bulletin No. 25, Dr. L. O. Howard says "the most satisfactory ways of fighting mosquitos are those which result in the destruction of larvae or the abolition of their breeding places. The three main preventive measures are the draining of breeding places, the introduction of small fish into fishless breeding places and the treatment of such pools with kerosene." Of the three methods suggested by Dr. Howard, let me recommend the top minnow, or similar fish, because it is always on the job and it is so easy to put off spraying with kerosene until painfully reminded that it is too late.

At the Cold Spring, Georgia, Station of the U. S. Bureau of Fisheries, this top minnow is propagated, or rather progagates itself, in the sunfish ponds. These ponds, six in number, covering an area of several acres, are located four miles from the home station and are admirably situated for the convenience of mosquitoes. Yet the custodian of this station reports that during the entire summer he was never bothered with mosquitoes while working about these ponds. I am sorry I can not say as much for the home station. Here some 200 wild, adult large mouth bass were introduced into the breeding ponds the past spring and, as they were not used to being fed, refused the chopped mullet thrown to them and promptly devoured the top minnows that heretofore had been quite plentiful. The result was a multiplication of mosquitoes.

Gambusia affinis was not native to the waters in the vicinity of the Cold Spring Station prior to about 1906. In that year, under the direction of a former superintendent, Mr. J. J. Stranahan, one can of about 200 top minnows was brought to the station from a lake near Colum-

bus, Georgia, forty miles distant, and from the Fisheries Station, during the years following, this little fish was introduced into nearby waters and now it is found in practically all of the ponds and streams in that vicinity.

The subject of my paper is viviparous (that is, it gives birth to its young, instead of depositing eggs as do almost all other fishes) and I have taken from the little bodies of the females from six to thirty young minnows. These females were from an inch and a quarter to two inches long.

In the early stages of its development the unborn young is enclosed in a sac or shell 3/32 of an inch in diameter. At birth the young fish is from 3/16 to ½ inch in length and at that time it becomes at once a free swimmer.

I do not know the exact duration of their period of reproduction, but from their earliest activity in the station ponds, about the first of March, the females contain well developed eggs and on October 15th, I found 24 young, in the egg stage, in a specimen two and one-fourth inches long.

When putting up bass and sunfish fingerlings for distribution, a few top minnows usually find their way into the cans with the other fish. These cans are placed under small jets of cold spring water over night to harden the fish in order that they may better stand shipment. The invariable report of messengers has been that the top minnows were very tender and that they died shortly after leaving the station. Accordingly it was decided to conduct an experiment that would determine the proper method of handling them.

The following is a memorandum submitted by Mr. G. H. Gill, fish culturist at the Cold Spring Station: "At 2:30 P. M. 250 top minnows were counted into a ten gallon can half filled with water. The fish were counted from the rearing ponds at a temperature of 65 degrees into tempered spring water at 67 degrees. The fish were placed under running water, 62 degrees, for the night, a very small stream flowing into the can. At 9:00 A. M. next day 30 dead fish were removed from the can

and the fish were allowed to stand for the remainder of the day, being bailed regularly. At 4:30 P. M. the fish were again placed under running water for the night. At 9:00 A. M. next day 35 dead were remove dand the spring water then renewed in the can. At the same time another lot of top minnows, numbering 200, were counted into a ten-gallon can half-filled with water, obtained from the rearing pond, temperature of water 65 degrees, and these fish, together with those formerly experimented with, were allowed to stand for 24 hours without a change of water and were bailed twice during this time, the temperature varying eight degrees, from 65 to 73. At the expiration of this time lot No. 1 was examined and a majority of the fish were found dead. Lot No. 2 was observed to have incurred a loss of one top minnow. The following deductions were made from this experiment: That top minnows are very susceptible to a sudden lowering of temperature and that they can not adjust themselves to such a change in a reasonable length of time, and that if they are to be transferred any distance or held for any length of time, the water from which these fish are seined should be used for the purpose. Also, that a rise in temperature does not affect the fish correspondingly." In this test reported by Mr. Gill, I believe the mortality of the minnows was due more to the superaeration of the water than to the change of temperature.

On Tuesday morning, October 10th, three ten-gallon cans of top minnows, of 200 each, were placed on the office platform. One can received no attention; the water in the second can was aerated at intervals for the balance of the day; the temperature of the water in the third can was reduced from 67 to 55 degrees, the lowering of the temperature being accomplished slowly by adding pieces of ice. Tuesday night the three lots of fish were in good condition and were left standing for the night without any further attention. The following morning these three cans, without any change of water, formed part of a shipment of 15 cans of top minnows which I took from the Cold Spring station to Augusta, Ga. They were in

transit from 7:50 A. M. to 5:30 P. M., were aerated only once, and this was not necessary, and they arrived in Augusta in good condition and with no loss. Of course the motion of the train carried a good deal of air into the cans.

At the time the three cans of fish, mentioned above, were put up, I placed about 25 top minnows in a white-fish jar containing a gallon and a half of water. Here they remained on my desk from Tuesday morning, without any change of water, until the following Saturday afternoon with a loss of half a dozen fish, only. When the fish were returned to the pond the water in the jar was foul, discolored and ill smelling and yet the minnows were apparently none the worse for wear after their 96 hours confinement in this small space.

Not among the least of the many new activities of the Bureau of Fisheries under the direction of Commissioner Smith, is the propagation and distribution into infested waters of the mosquito destroying fishes and I believe that great good will come from this practice when the fact that the Bureau is prepared to supply such fish is better known.

BASS REARING IN TEXAS

By Mark Riley, *San Marcos, Texas.*

The output of bass from the San Marcos Station during each of the past four years, while exceeding that of any previous year by many thousands, has not been entirely satisfactory to its superintendent. Many letters of commendation relative to our work have been received and the Bureau of Fisheries has been particularly appreciative, yet, while such commendation is gratifying, the fact remains that we know so little relative to the natural propagation of fishes that the results of our well-meant efforts too often prove fruitless. Pond culture has many vexing problems and no doubt a solution that will apply on one station may prove useless on another. Had the privilege of attending a meeting of superintendents each year been possible, I am confident that the results accomplished from applied information there obtained would have well recompensed the Government for the slight expense so contracted, for one who can not acquire valuable ideas from associates engaged in the same line of work and utilize them for his own particular needs, in my opinion, falls far short of getting the best possible results from the station over which he has supervision.

The greater part of our work at the San Marcos Station is with the large-mouth black bass, the small-mouth being unknown in the state to the best of my knowledge. Our methods are practically those employed at other pond cultural stations, judging from the information that I have been able to gather, for as yet I have never had the pleasure of visiting other stations and observing for myself the work of my associates. It is well known that different people have different ways of doing the same thing, so a short description of our work may result in some criticism or suggestion that will be of benefit to the station at San Marcos, in which event I will be well repaid.

Just at this time of the year, unless the weather should be unusually warm, our ponds are being cleared of the rank vegetation that covers them. First a large space is cleared in front of the outlet. Then the employees with scythes and rakes commence on the outer edges of a pond and cut and pile all moss and weeds, following the water which is slowly drawn from the pond. As the fish enter the cleared place in front of the outlet, they are from time to time taken from the pond with a seine, assorted, the young placed in pools for distribution and the brood fish held temporarily in another pond during the time the pond is being cleaned and dried out for the next season's work. At the last the few remaining fish are carefully picked up with a dip net. Selecting a cool day, we have no loss in so drawing a pond and the fish are taken therefrom in good condition. Should there be bass that are very thin and plainly showing that they will not spawn during the coming year they are liberated in the San Marcos River which forms our eastern boundary. Just as soon as the bottoms of the ponds will support a wagon the piles of moss are removed and carted away. Should rains interfere with the drying it is sometimes necessary to carry the moss to the banks with forks. After the bottoms of the ponds are dry they are scraped and the sediment also removed. We have had very good success, both last year and that preceding in using the road grader of the city for that purpose, six mules drawing the grader and the man at the wheel shaping the bottom evenly and with rapidity, the sediment being thrown in rows convenient for shoveling into a wagon.

The pond cleaned, it is ready for the nests of gravel, all large stones having been removed from the same. These nests are placed about 20 feet apart and ten feet or so from the banks, with a number in the center of the pond where the water is shallow. Screens are placed on inlet and outlet and the pond is filled with water. All of our bass ponds at the present time are filled by pumping from the San Marcos River, the two pumps being run by gasoline engines. Those of you who know the engine

of many moods will sympathize with me, and if there are stations where power other than gasoline is used, their superintendents have missed much that would have had a tendency to add to their vocabulary of forceful English. However the tender heart of our Assistant in Charge has been touched by my lamentations and I have reason to hope that our station will soon receive a better supply of water more economically in the near future.

The brood fish are carefully selected from our stock, an effort being made to get three females to every male, but unless the fish are well developed there is more or less uncertainty in the selection and very often the percentage of females is a little greater. Of course our station, being so far south, has an early season and we have fish spawning in February and March and, as a matter of fact, some bass can be found spawning every month of the year. It may be that here the bass spawn more than once each year or possibly all eggs are not thrown off at one time.

Usually we commence our distribution about the first of April, sometimes a little earlier, depending of course upon water and air conditions. Sudden drops in temperature cause us much trouble and frequently considerable loss of fish in the fry stage. These sudden changes at San Marcos will cause the bass to leave the nest, the sudden change kills the eggs and the anticipated large school of fry proves a minus quantity. This catastrophe I try to avoid by pumping the warm water of the San Marcos into the ponds and so raising the temperature. Our river has its source near the hatchery where it bursts forth in springs from beneath the hills and has a uniform temperature of about seventy-three degrees. A number of times when the approaching "norther" has given warning, I have been able to guard against losses in this manner.

As soon as a school of fry is noticed, it is kept under close observation and, when reaching the size of No. 1 fingerlings, is taken from the pond with a bobbinet seine, placed in a tub, carried to our retaining apparatus, counted into buckets of water and carefully poured into

the cans, which have been previously filled about half full of water. A circular piece of screen wire is placed on top and a jet of water turned on the can to run pending shipment. This arrangement is rather crude and a little air mixer has been perfected which will probably be installed in the near future. At the San Marcos Station the fish are always counted from the tub to the buckets before placing in cans for shipment. Two or three men do the counting and another keeps the buckets filled with water and empties the fish into the cans. The small, square, aluminum-framed nets are used and each man has a block of wood one inch square, with ten holes bored on one side, a small peg fits these holes and when 100 is reached in counting the peg is moved forward one place so that the number may not be forgotten if the attention of the one counting is called to something else. The practice of counting one bucket of fish and making others look like it has never been in use with us and while an actual count is slower than such an estimate, in my opinion, the actual count is more satisfactory. If a large output of statistics is desired I certainly recommend a practice other than that we employ.

The largest school of young bass that we have ever caught was 32,000 No. 1 fingerlings. There is some doubt in my mind as to this number being hatched on one nest, but, being accompanied by a parent fish when caught, and there being no other brood fish near, it is possible that this great number came from a single nest, but it is unusual with us to have such large schools. It seems to me that some system of uniform counting should be adopted at the pond cultural stations and that we should rigidly adhere to the method. A great English writer is quoted as saying, there are lies, there are damned lies, and statistics, and possibly he could have gone a step further and added there are estimates.

A recent report of an official said it was the purpose of the Bureau of Fisheries to deliver results and not statistics and I honestly think that no pains should be spared to make our output accurate. If there is a better way to

secure greater accuracy than our present method I am ready to adopt it, after being convinced. I am quite sure that, with us, "estimating" would not be so satisfactory to the applicant, for frequently I receive letters from those who have received fish telling me of the safe arrival and that a few more than stated in the allotment for which they signed the receipt.

The railroads of Texas carry our fish as first class freight and handle the cans as baggage in the regular baggage cars. One attendant may accompany a shipment free and no shipment can exceed fifteen cans. The empty cans are returned free. These shipments are billed on regular Government bills of lading, shipped by the superintendent and consigned to the accompanying messenger at place of delivery, the original bill of lading being accomplished by the consignee at the place where fish are delivered to applicant. Where transfers can be made by messenger cheaper than charges made by railroads for the same service, the accompanying messenger pays this charge and takes up the same in his expense account. While possibly the method is more complex than that which obtains elsewhere, still, in the main, it is satisfactory, although increasing the clerical work of the station.

During recent years the greater part of our distribution work has been done by the station force, which it appears to me is more economical than detailing a car messenger or assigning a car for the work. The former plan we tried and the work was satisfactory, as we were fortunate in getting energetic, capable men. In one respect it is a disadvantage to have the work done by the station force. More temporary labor must be employed on the station if the men are on the road and the pay for the men so working comes from the station allotment, which in past years I have found falls short of what I would like for the maintenance of the station. However, should every superintendent have all the money that he desires, probably the Bureau of Fisheries would need an appropriation equal to that of the War Department. My experience has been that laborers on a station perform-

ing the work of messengers think, and they have some grounds for the opinion, that if they do the work of messengers they should receive the same salary as messengers. Previous to my appointment as superintendent, the laborers at San Marcos had done no work of distribution. They were ignorant of the methods of carrying fish, making out messenger, mileage, or other reports, as well as making out accounts against the Government. That is no longer the case, for at the present time every member of our force is familiar with all of the details of distribution, with the railroads of the state and points of transfer, as well as being proficient in all clerical work required of messengers, and in fact they are well qualified for positions as fish culturists on any station where the Bureau of Fisheries may require their services.

PROPAGATION OF SMALL-MOUTH BLACK BASS

By O. P. Cushman, *Mammoth Spring, Ark.*

Of all the fishes propagated in ponds none is more susceptible to careful handling than the small-mouth black bass, and the fish culturist who knows the requisites for the successful propagation of this species may always be well rewarded for his efforts.

Successful bass culutre looks to the production of the largest possible number of fry, and the securing from these fry of the greatest possible number of good sized fingerlings.

These results can be guaranteed when favorable conditions exist in the water supply, the brood stock, the spawning pond and in the rearing pond.

Water Supply

The ideal water supply is spring water with a high temperature, strongly impregnated with lime, and that never becomes roily. Clear water insures a good yield of fry, while roily water means sure death to the eggs. It is believed that foul water has destroyed more bass egs than all other causes combined. The fertility of the eggs will be effected in proportion to the impurity of the water until all may be lost.

The roiliness of the water in the spawning pond may be very misleading to the fish culturist. If the water is just a little muddy, and every nest produces some fry, there may be a heavy loss and the fish culturist fail to detect the cause, for the reason that every nest produces some fry.

The act of setting the nests near the spawning time will reduce the yield of fry. Tramping over the pond bottom, setting the nests, and the water pouring into the pond over the fresh earth in filling up the pond, all

tend to leave the water more or less roily. For this reason the nests should be set long enough before spawning time for the water to become perfectly clear before spawning begins.

High temperature in the water supply is desirable in case of a sudden drop in the air temperature to the extent that it would lower the water temperature to the point where the adults may abandon the nests. If a large supply of water with a high temperature is turned into the spawning pond, its is possible to keep the temperature of the pond above the danger point.

Brood Stock

Good sized adults are preferred for breeders, as the size of the schools of fry will be in proportion to the size of the adults. Other things being equal, success will be marked in proportion to the size of the adults. All adults under one pound should be discarded.

If native stock is to be collected for breeders, it is desirable that it be secured in the fall. The fish then become accustomed to their new environment before spawning time and will produce more spawn than if collected in the spring.

A good brood stock can be obtained by rearing young bass to adults on artificial food. With a brood stock thus reared, the food problem is solved and the breeders will always be in good shape at spawning time, which is a very important requisite for a good yield of fry. When young bass are to be reared for breeders, they may be taken from the pond when one or two inches long and placed in troughs or tanks where they can be taught to take artificial food. When they are about three inches long and are taking food well, they should be transferred to a small pond in order that they may have more range.

These young bass will spawn when two years old, the average number of fry for each female being about five or six hundred the first year, the number increasing as the fish grow older and larger.

Much difficulty is experienced in getting adults captured in their wild state to take artificial food, and there are always quite a number that never can be taught to take it. To meet this difficulty branch minnows should be collected and given them.

Whatever the food may be, it must be given in amount sufficient to keep the fish in good condition, as good results cannot be obtained with breeders that are poor or starved.

Spawning Pond

The spawning pond should be large enough to contain enough nests for all the adults. A pond containing an area of one, or one and one-fourth acres would be large enough for three of four hundred adults, which should produce sufficient fry for five or six rearing ponds each with an area of one acre.

From one-half to two-thirds of this pond should have a depth of eighteen to twenty-four inches in which to set the nests, twenty-five or thirty nests to one hundred adults being about the right proportion.

It is advisable for the following reasons to confine all adults in one pond. First, you get the benefit of all the males, whereas, if adults are divided and placed in several ponds there is likely to be a surplus of males in one pond and a deficiency in another. In the latter case there will be a loss of eggs through lack of fertlization. Second, by confining all the adults in one pond, the remaining ponds will be available for rearing fingerlings. Third, the spawning season extends over a period of several weeks, which makes quite a difference in the size of the fry of the first and the last spawn. This makes it necessary to have separate ponds in which to place fry of different ages.

Rearing Ponds

The biggest problem in bass culture is the rearing of young bass to good sized fingerlings. This problem is solved in the rearing pond. The rearing pond is to the

efficient bass culturist what the clover field or pasture is to the successful stock raiser, and the efficient fish culturist looks to it as the key to ultimate success. With this object in view, the most important factor is an abundance of vegetation in the rearing pond.

Next to the supply of clear water in the spawning pond the most important requisite in bass culture is the aquatic vegetation in the rearing pond, and its abundance. Though the pond should contain an abundance of food for the young bass, a deficiency in vegetation will lead them to prey upon each other in preference to taking such ideal food as gammarus, or fresh water shrimp. Aquatic vegetation not only makes this food available for the young bass, but it serves as a protection against cannibalism.

These conditions being provided, when the fry are ready to be taken from the spawning pond, the rearing pond will be well suplied with such food as daphnia, or water flea, and as these become exhausted and the young bass require larger food, the gammarus or fresh water shrimp is available.

In case the rearing pond should be over crowded with young bass, and the animal life may not be sufficient to rear all of them to good sized fingerlings, a good idea is to seine out part of them for distribution after they have reached the size of number one fingerlings, but good sized fingerlings are superior, as they are more able to take care of themselves, in escaping cannibalism of other fishes, and finding food.

Summing up, if these requisites are maintained the fish culturist should not fail.

Clear water in the spawning pond of proper minimum temperature and ingredients.

Adults always well fed and in good condition.

Spawning pond large enough to contain nests for all the adults.

Enough rearing ponds so that fry of different ages may be placed in different ponds, and these ponds well supplied with aquatic vegetation.

SOME OF THE LAWS AND METHODS FOR THE PROTECTION AND CONSERVATION OF LOUISIANA'S FISH

By E. A. Tulian, *Superintendent, State Fisheries Department, New Orleans, La.*

I believe that no state in the Union has been provided with better and more far-reaching laws, rules and regulations for the protection and conservation of its fishes than the State of Louisiana. Few equal ours in this respect. The matter of protecting and conserving the more valuable species of our fresh water fishes, has been given the greater share of attention up to the present time. However, our salt water fishes have not, by any means, been neglcted in this particular. When considering what laws were necessary to obtain these results, the Department of Conservation, and its predecessors, have invariably given most careful thought and study to the subject of accomplishing the maximum of good with a minumum loss to those dependent upon our fisheries resources for a livelihood.

Under the laws creating the Department of Conservation, the Commissioner is authorized to adopt such needful rules and regulations, not in conflict with any of the provisions of our laws, as may be found necessary for the proper and intelligent administration of all the conservation laws of this state.

One of the strongest features of our fish laws, from my point of view, is that which limits the kind of nets which may be used in our waters for the taking of the common commercial species of both fresh and salt water fish. This legalizes only two classes of nets, the common hoop-net, and a drag seine not exceeding a certain length, and manufactures of twine having a mesh of a certain size. It is not only unlawful to use trammel-nets, gill-nets, fyke-nets, etc., in our waters, but the law states that it

shall be unlawful for any person found within the boundaries of Louisiana to have the same in his possession. It is contended by some, and probably rightly so, that trammel-nets are less destructive than drag seines to all the life found in our waters, if set in the open sea, or in large lakes. Our experience has been that if trammel-nets were allowed to be brought into the state they were invariably used in bayous, streams and narrow bays, and set completely across them, thereby taking nearly every fish above a certain size that would be making its way either in or out of said bodies of water. The State of Louisiana has hundreds of miles of such waters, both fresh and salt, and it would certainly be very detrimental to its fisheries resources if trammel-nets could be used in these waters.

Another admirable feature of our seining laws, prohibits the using of any seine over 900 ft. in length, and having not less than a six-inch stretched mesh, for taking any of the common commercial species of fresh water fish. Under this section of the law, no two or more seines may be joined together and used as one seine. The penalty for doing this, is the confiscation of the license and permit under which the owner of the seine is operating, in addition to the usual fine. Seines being operating under our license and permit can only be used in certain permitted waters of the state where, in the opinion of the Commissioner, it can be shown the using of them is not detrimental to its interests. The license and permit under which any seine is being operated in certain waters, may be revoked whenever it is shown by fisheries experts that seining therein is detrimental to the game fish resources of the state.

Our law as regards hoop-nets is excellent, inasmuch as only plain hoop-nets; that is, those without leaders or wings, may be used in any of the waters of this state. Then again these may not be set in any one of our bayous, streams, or lagoons, which is less than forty yards in width at low water mark.

Louisiana has a most excellent close season law for the protection of its three most valuable commercial species of fresh-water fish. These seasons were fixed primarily to cover the greater portion of the spawning period of the paddle-fish, buffalo-fish and catfish respectively. It prohibits the taking of paddle-fish every year between the 1st day of January and the 15th day of July; the taking of all species of buffalo-fish between the 15th day of February and the 15th day of April, and all fresh water catfish between the 15th day of May and 15th day of July. In the case of the paddle-fish, the close season extends some months beyond the time when the last of them have finished spawning. This was found advisable, however, as a precaution against a former practice of selling dressed catfish as paddle-fish during the catfish close season. Besides the exceptional high value and ever growing scarcity of this species were considered additional good reasons for the close season of six and one-half months of every year. A close season of only two months for the buffalo-fish and cat-fish each was fixed with the full realization that a considerable number of both species found in the southern portions of the state would have spawned before the close season had commenced, while a great many of those in the northern sections would not have finished by the end of the same. However, it was hoped, that the results attained by this somewhat shortened season would justify the belief that it was unnecessary to inflict a close season longer than two months, for each one of these species, upon those engaged in exploiting the commercial fresh water fish resources of Louisiana. Such appears to have been the case.

Further protective measures, adopted to work in conjunction with our close seasons and other commercial fresh water fish laws, provide:

1. If any species of fresh water catfish, or buffalo-fish, less than twelve inches in length are taken by any legal methods, they must be immediately returned to the waters from which taken without avoidable injury.

2. If any paddle-fish not containing roe suitable to be manufactured into caviar, are caught, the same must be liberated at once, and without unnecessary injury.

3. All garfish taken, both large and small, must be killed, and all those that are thrown back into the water from whence taken, must be cut open along the entire length of the belly, if twelve inches or more in length.

4. No seine operated in fresh water, may be hauled nearer than 100 ft. to the shores of any body of water in which it is being used. It is never to be hauled out upon any of the shores of such bodies when finishing a haul, but is to be pulled up under an apparatus usually called a "round up," or some similar device, and it is to be landed into a boat, or upon a raft or some other floating device.

5. It is illegal to splash or pound upon the water, or to pound upon a boat, the banks or any other object, for the purpose of driving fish into a seine or seines.

6. All vegetation hauled out with a fresh-water fish seine must be carefullw removed from it, and immediately put back into the water. The vegetation thus returned must be carefully scattered so that it will not sink in bunches to the bottom of any body of water.

7. It is unlawful for any person or persons to muddy or "puddle" any waters for the purpose of taking fish therefrom.

8. All intake pipes used for the purpose of drawing water for irrigating purposes must be adequately screened.

9. No bayou, lagoon, lake, bay, river, or any other body of water may be obstructed by means of rack, screen, wire, or other device so as to prevent the free passage of fish.

10. Our law is very severe upon those who may be convicted of killing fish by means of dynamite or any other explosives, or who may throw into, or allow acids, lime, india berries, sawdust, green walnuts, walnut leaves or any other deleterious substances to run into the Gulf of

Mexico within the territory of jurisdiction of the State. The penalty for violation of any of the above only admits of a jail sentence of from five days to twelve months and the cost of the prosecution. The alternative of a fine is not provided for.

In addition to the protection afforded them through the laws and regulations already mentioned in this paper, all fresh water game fish found in our state, such as black bass, crappie, white bass, yellow bass, and all other species of bass and sunfish are furthermore amply protected. The main protection is afforded by the manner in which they may be taken, a limit to the number that may be taken in any one day by any one person, and the non-sale of the same.

Our law declares that it is illegal to take, or have in possession for use, any of the heretofore mentioned game fish if taken by any other method except rod, hook and line, hand-line, or trolling-line. Not more than twenty-five bass or 100 sunfish may be taken by any one person in any one day, the take to be confined to the apparatus mentioned. All bass measuring less than eight inches in length that may be taken, must be returned at once to the waters from which taken and without unnecessary injury. None of the aforesaid game fish may be sold within the boundaries of Louisiana, no matter whether taken from within or without the state.

Those fish found in privately owned lakes and ponds are the property of its owner, only if propagated and maintained in captivity. All fishes brought into private waters as the result of overflows from public waters, remain the property of the state.

Any body of public fresh water within our state may be set aside for an indefinite period by the head of the Department of Conservation for the purpose of providing a natural propagating and rearing place for fish.

The taking of any species of fresh water fish from any of the public waters may at any time be prohibited for a series of years not exceeding three, when it is deemed to be for the best interest of the state to do so.

Partly because it has not yet been deemed necessary to have them, and partly for the reason that the exact spawning season of each of the several more important species of salt water fish has never been accurately determined, so far as our territory is concerned, Louisiana has no salt water fish close seasons. However, it is realized that the same will soon be necessary and investigations have been made from time to time with a view to locating their different spawning grounds within this state, as well as their spawning period.

Net fishing for the taking of salt water fish, from waters within the territory of the jurisdiction of Louisiana, is limited to drag seines and hoop-nets; as is done in the case of fresh-water fish. There is no limit to the length of a seine which may be used for taking the former. The cost of a license under which to fish for salt water fish with a seine is based, however, on the length of it. Hoop-nets must not have leaders or wings attached, and must not be set in any body of water less than forty yards in width at low water mark.

It is illegal to take, or have in possession, any salt water fish less than eight inches in length other than bream, croakers, or sea perch. The law further prohibits any person, firm or corporation engaged in the salt water commercial fisheries, from buying any speicies of salt water fish measuring less than eight inches in length.

Seines when being hauled for salt water shrimp often bring in large quantities of salt water fish. In that case, those that are found to be injured or dead may be retained, but those hauled out alive and uninjured must be liberated as the seine is brought out of the water. A great many fish are destroyed annually by shrimp seines as a majority of those hauled in with a fairly good catch of shrimp, are either found to be dead or badly injured. The larger proportion of such are usually left to be destroyed by birds and animals, especially the smaller fish which cannot well be used for food. There does not appear to be any practical method of preventing this. A

lot of these fish are brought into our markets, but it is undoubtedly true that a great many of the small salt water fish found there, were not taken with shrimp seines. We need more stringent laws to govern this and a most rigid enforcement of them, if we would minimize this needless destruction.

Matters relating to the shrimp and the diamond-back terrapin industries come under the jurisdiction of the Fisheries Department and we have also excellent laws for their protection and conservation.

The American Fisheries Society

EDITORIAL

The Matter of Dues. The Acting Treasurer reports that a good many members of the Society seem to be in doubt as to the time when the annual membership fee falls due. According to a long established custom, dating back apparently to the first meeting in 1870, this fee falls due at the time of the annual meeting and, on payment, the member is entitled to all privileges at that meeting and up to the beginning of the succeeding annual meeting. Thus a member who paid his dues at the 1915 meeting, or afterward when notified by the Treasurer, would be entitled to all the privileges of membership up to, but not including, the 1916 meeting. At the time of the 1916 meeting the fee again fell due, as fees should be paid in advance to entitle members to receive the Transactions. This interpretation is based on the unanimous opinion expressed by a number of the past and present officers of the Society.

It should be added that in case a member is elected after the annual meeting his membership dates back to that time, unless he expressly desires to begin with the next annual meeting, and he is entitled to any back numbers of the Transactions included in the volume current at the time of his application. The misunderstanding evidently rests on the fact that the fiscal year of the Society does not correspond to the calendar year, but runs from one annual meeting to the next.

Back Volumes of Transactions at Reduced Prices. At the last annual meeting of the Society it was decided to offer back volumes of the Transactions *to members only,* at half price. This action was taken for two reasons: First, to encourage the more recently elected members to increase their libraries on fisheries matters by the addition of volumes of the Transactions antedating their membership. Second, to increase to some extent

the immediate revenues of the Society and, at the same time, to help solve the problem of storage of these volumes. As there are in several cases as many as 200 copies of these back volumes on hand and as series covering a number of years can be supplied, it is hoped that numerous members will avail themselves of this opportunity. Until the Society sees fit to rescind this action the 1910 volume will be sold at $1.00 and all other volumes at $.75 to members only.

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